Proceedings of the Institute of Acoustics

The Quality of Quantification

by Frederick J. Ampel MInstSCE [1] and Ted Uzzle MBKS [2]

[1] Editorial Director, *Sound & Video Contractor* magazine, Overland Park, Kan., USA.
[2] President, Kinotic Press, Oklahoma City, Okla., U.S.A.

INTRODUCTION

Those present at last year's Institute of Acoustics conclave had the opportunity to be participants in a unique event. For the first time since the introduction of the prototypical audioCAD program in 1983, all of the corporate sponsors of software used for acoustic analysis and design gathered in once place to discuss and expound on their products. As many of us suspected, the debates and exchanges that occurred gave rise to at least as many questions as they produced answers.

Since the fall of 1990 the discussion has continued. Those who have followed it with any regularity realize that we have really only begun to scratch the surface of many of the more complex issues surrounding this topic. One of those new questions that came out of the dialogues held here, was, what should we actually call this product category? Remember during today's discussions and forever more that these are *indeed* products like any other!

Since their inception we have always referred to these programs using a name adopted from software produced for other purposes—the now ubiquitous *CAD* as in computer aided (or assisted) design.

That acronym more and more came to be both inaccurate and misleading as program capabilities continued to grow and enhancements proceeded. A far more accurate acronym, the result of serious cogitation and presented here for adoption, is AADS —that is, *A*rray and *A*coustical *D*esign *S*oftware. We suggest this because if you take a careful look at the primary functions offered by any of the programs currently available, you will easily see that they all cluster (no pun intended) about two distinct areas. The first is loudspeaker array design and device positioning. The second is acoustic space or room information analysis. More on that later in this paper.

A second and more important quandary that appeared during last year's discussions was the matter whose name provides the title of this paper—the quality of our quantification capabilities.

This issue arises because we must be considerably more cautious in accepting the progeny of our microprocessors. As an industry we have caught a potentially lethal case of rampant microprocessorization. Those little chips are everywhere, and in everything—sort of like the mythical tribbles from the old *Star Trek* television series (National Broadcasting Company, 1966-1969).

The problem is that any computerized device or computer system, running any software, or generating any measurements we are likely to acquire or need, is a number-intensive system. It lives and breathes digit after digit, but it knows them not. It cannot tell you that these numbers are right and those are wrong; it simply crunches and crunches until some answer appears on your display. If that answer is not to be unadulterated hogwash, then the quality of the inputted data must be our first consideration, and more often than not, that issue is most carefully not discussed.

And that grey area is what brings us to this morning's discourse.

Before we dive headlong into the microscopically-focussed world of computer-aided measurements that often end up being the basis for the data inputted into the AADS software, we should take a look back to see how we got to the current state of the measurement and quantification art. Please note the use of the word art, not science, for there still is and probably always will be a certain subjective factor to all this audio stuff.

THE QUALITY OF QUANTIFICATION

THE HISTORICAL PROBLEM

We have fashioned and manipulated sound since before history, and done it rather well, actually. We invented music, and over thousands of years nourished our souls with music of captivating, sometimes ravishing beauty. We invented oratory, and drama, and built magnificent, often monumental places where we could assemble to hear them. But the actual stuff of sound remained a mystery. Over those same millennia the needs of commerce drove the invention of dozens of types of measures—forms, if you will, of quantification. We devised and implemented systems and units to specify length, weight, and capacity, but with all this activity we still failed to find a way to measure sound. It is invisible, it leaves no mark, there is nothing to hold a ruler against. It is weightless; there is nothing to capture in a bottle.

Finally, in the second half of the Seventeenth Century, the invention of the calculus created, almost overnight, a revolution in our understanding of acoustics, but it was a singularly arid understanding. Now we had formulæ for densities and elasticities, the displacements of strings, superposition and propagation, plates and shells: they march page after page after hundreds more pages and endless thousands of equations through Lord Rayleigh's *Theory of Sound*.

One staggers away and gasps for air and sunlight, for a simple statement that sound does this or that. These were not forthcoming. The new mathematical techniques created a huge, powerful machine for processing and analyzing experimental results, but there were no experimental results.

THE SEARCH FOR RESULTS: THE SPEED OF SOUND

Homo sapiens has known, if not quite understood, from the earliest days of sentience, that light and sound travel at different speeds. Clearly the flash of lightning and the boom of thunder, together with the location of a tree exploded and burnt to ash, taught this to our ancestors.

However, the earliest measurements of the speed of sound, that we could recognize as having been done with any degree of scientific accuracy and understanding, were not made until the Seventeenth Century. Those first quantifications were achieved by Pierre Gassendi (1592-1655) and by Marin Mersènne (1588-1648).

Mersènne used a pendulum to measure the elapsed time between a flash of gunpowder and the explosive sound. Gassendi in 1635 used a mechanical timepiece. Gassendi also noted, although he could not explain, that the crack of a musket and the boom of a cannon, distinctly different sonic phenomenon to his way of thinking, were transmitted with the same speed, using his (crude by our standards) measurement system.

In what could be judged to be a prescient moment, these two experimentalists were careful *not* to assume light propagation to be instantaneous. They carefully specified as well that they measured and noted the difference between the speeds of light and sound.

In 1687 Isaac Newton (1642-1727) published a prediction of the speed of sound, given the density and elasticity of air (remember the arrival of calculus). Newton's friends John Flamsteed (1646-1719), the astronomer royal, and Edmond Halley (1656-1742), the comet discoverer, attempted to verify Newton's prediction by watching through a telescope from the Greenwich observatory, while a cannon was fired at Shooter's Hill three miles away. To their utter mortification they discovered Newton's prediction to be almost 20% too slow.

It took more than 50 years, and the French, to arrive at an accurate number. Finally in 1738 the Academy of Sciences in Paris announced a speed of sound within one-half of one percent of the value widely accepted today.

THE QUALITY OF QUANTIFICATION

THE EIGHTEENTH CENTURY—ACOUSTICS ARRIVES

Suddenly, and almost inexplicably, the Eighteenth Century brought a burst of advancement. Promptly as the century opened in 1701, Joseph Saveur (1653-1716) published the word *l'acoustique* in a paper for L'Academy Royale des Sciences, and named once for all our craft or sullen art.

In 1705 the works of Robert Hooke (1635-1703) were published, including a description of a toothed wooden wheel he would rotate while holding a stiff card against it. He devised wheels with musical tones, and wheels that imitated speech, describing the regularity of the one and the irregularity of the other.

Much later, in fact almost 100 years to be exact, Félix Savart (1791-1841) would invent the mechanical tachometer, to measure rotational velocity. This allowed the accurate measurement of the frequency of tones produced by such devices as Hooke's wheels. With the whimsey of history, his invention of the tachometer would be forgotten, but the part of the device he took from Hook would be called "Savart's wheel."

Standing alone, and singing out to us today with a clear and pure tone is an invention from 1711. This simple invention would become a vital part of music, acoustics, and medicine, and reigns today in music as a sovereign remedy.

John Shore (1662-1752) was sergeant-trumpeter to His Royal Majesty George I, and the third in his family to occupy that office. His skill was so revered that wonderful and delicious trumpet music was composed for Shore by G. F. Handel (1685-1759), and especially Henry Purcell (1659-1695). Much of that work is still performed today, and modern players stand in awe of Shore's range and skill. However, it was not for his embouchure that Shore is legend in the lexicon of acoustic measurements. No!

In 1711 he made his first tuning fork, and called it, with conscious good humor, a "pitchfork."

Thus, a frequency standard was invented we can still refer to today. Shore gave us an instrument that would dominate acoustics and psychoacoustics for over two hundred years. In fact, tuning forks preserved from past times keep our musical heritage true, no less than the invention of the metronome, almost exactly a century later, by Johann Nepomuk Mælzel (1772-1838).

THE NINETEENTH CENTURY—A SCIENCE BEGINS

In 1802 the German Ernst Chladni (1756-1827) used the acumulation of sand at antinodal points on a vibrating body to form Chladni patterns. Thus the behavior of certain types of plates and shells could now be measured.

AT LAST, VISIBILITY

In 1807, Thomas Young (1773-1829) blackened the outside of a cylinder with lampblack, and rotated the cylinder. Now a pin pushed through a diaphragm could scribe its actual motion on the lampblack, and sound waves were visible for the first time.

Leon Scott would develop this concept further by adding a horn to collect airborne sounds more effectively, and his phonoautograph of 1856 presaged Edison's phonograph by twenty years. As an acoustical instrument, it was further developed by Dayton C. Miller (1866-1941), who called his device the phonodiek, and others.

In 1857 Jules Lissajous (1822-1880) was manufacturing tuning forks in France, and he needed a way to tune them quite precisely, in a factory environment. In one of those strange connection routes that science often takes, he hit on an optical method of great elegance.

He turned two tuning forks at right angles to each other, so one vibrated horizontally and the other vertically. Shining a spot of light onto a tine of one fork, he reflected it onto a tine of the other. This spot of light could be viewed through a lens system, and later projected onto a screen. Eureka—now frequency ratio, amplitude ratio, and relative phase were all revealed by the patterns created this way. Later Hermann Helmholtz (1821-1894) would replace one fork with a horn and diaphragm arrangement, so that sounds captured from the air could be compared with a fork of known pitch.

In the 1920's Maximilian Julius Otto Strutt (1903-), then working for N. V. Philips in the Netherlands, showed the first chart recorder with ultra-high writing speed. He used a further elaboration of Miller's phonodiek. This device, built for Strutt by Siemans and Halske of Germany, used a horn with a diaphragm at the small end, and a mirror on the diaphragm. The mirror would deflect with the vibrations of the diaphragm. The optical system used a spot of light shining into this mirror, but this time the spot of light was captured by a moving ribbon of cinema film. By using an appropriate lens, the deflection of the spot could be logarithmic. A later version used electromagnetic shutters developed for optical sound on film. Strutt made chart recordings on 35 mm film of reverberative decays, and thus studied what we today call the fine structure of reverberation.

We have described this in detail because his work was published once only, in German, and never translated ("Raumakustik" in *Handbuch der Experimentalphysik*, 17:2, 1934, pp. 443-512). Strutt took up other scientific endeavors after 1934, leaving acoustics altogether, and this brilliant work is utterly forgotten today.

THE PROBLEM OF AMPLITUDE

By now, you will have probably noticed a strange omission from all these devices. There was no means to measure the amount of sound, no measurement of sound amplitude. This is because the first such instrument didn't appear until 1882!

It was the Rayleigh disk, invented by Lord Rayleigh (1842-1919). The Rayleigh disk apparatus uses a small, light, metal disk so arranged in a chamber that if a sound wave is travelling through, the disk will deflect in proportion to the particle velocity of the wave. It is an absolute measurement of volume-velocity, the analogue of current in Ohm's law, but specific to acoustics.

The Rayleigh disk was a wonderful breakthrough, the first machine for measuring the last axis of acoustic variability: amplitude, or more simply how much sound. Unfortunately, the Rayleigh disk was a most delicate apparatus, not capable of being used outside the laboratory, and within the lab capable of being used by only skilled technicians.

At just the moment the Rayleigh disk was coming into use, an obscure medical device was being cooked up in France, which would come to have huge implications for measurements of all kinds.

Jacques-Arsène d'Arsonval (1851-1940) was a physician and medical researcher experimenting with electrical currents in the body. He needed an instrument that would measure the electrical parts of the human electrochemical anatomy. He cobbled up the moving-coil galvanometer, the preferred works in analog meters from that day to this. He called it a galvanometer (and we sometimes use this term today) in analogy to the experiments of Luigi Galvani (1737-1798), who would make a frog's leg jump by passing an electrical current through it. In something like the same way, d'Arsonval's meter needle jumped when a current was applied.

Although the carbon button microphone had been invented by Bell (1847-1922) in 1876, it wasn't until 1908 that George Washington Pierce (1872- 1956) thought to connect one to a d'Arsonval meter and measure sound amplitude.

THE ELECTRICAL ERA

The rest, as they say, was history. Purely mechanical instruments would die hard in acoustics, however. Arthur Gordon Webster

THE QUALITY OF QUANTIFICATION

(1863-1923) continued to build mechanical sound meters and mechanical oscilloscopes until his death, and wrote in 1919, "I believe I can give more satisfactory answers to all of these telephone engineer's queries than can be got by the instruments he gets up by himself. They are handy, no doubt, and all that... [but] I do not do it that way."

By 1919 the mechanical era of acoustical instruments was over, however. In 1917 engineers at Western Electric's laboratories (to become the Bell Labs in 1924) combined four devices to create a practical, if inconvenient, sound level meter. These devices were:

- *the thermophone*, a reliable calibrator consisting of strips of gold foil with an electrical current flowing through them, developed by Harold D. Arnold (1883-1933) and Irving B. Crandall (1890-1927), at the Bell Labs;
- *the electrostatic microphone* (or "condenser" microphone) developed by Edward C. Wente (1889-1972) at the Bell Labs;
- *the amplifying valve* (vacuum tube) developed by Lee De Forest (1873-1961); and
- *the galvanometer* developed by d'Arsonval.

Thus we can rightfully say that 1917 marks the beginning of practical acoustical measurements using electronics.

THE ANECHOIC CHAMBER

Most acoustical measurements of devices were made outdoors for some years, and what we now call the anechoic chamber was developed during the 1920's at the Bell Laboratories. Oblique references to "well-damped measurement chambers" appeared in Bell publications from 1924 to 1936, when E. H. Bedell finally published a paper describing wedges of fuzz in a strong room from which outside sounds and vibrations were excluded. While we cannot prove it, one might suspect these inventors toyed with the idea of keeping the anechoic chamber a trade secret.

LESSONS FROM THE EARLY DAYS OF ACOUSTIC MEASUREMENTS

We should not be surprised acoustic measurements did not begin until the Seventeenth Century, nor that the most basic measurement, sound amplitude, could not be made replicably until 1882. While acoustic and musical lore were assembled since antiquity, the ancients couldn't be bothered to measure. Aristotle (384-322 BC) wrote that high pitches would be transmitted through the air more quickly than low pitches. He had easy access to all the apparatus he needed to disprove that theory, but he didn't bother, and it wasn't disproved until Gassendi did so in 1635. What changed with Galileo (1564-1642) wasn't available technology, but rather the desire to test, to experiment, to measure.

We should not be surprised our acoustic test devices came from elsewhere. Lissajous patterns were discovered in order to manufacture tuning forks. The moving-coil analog meter was invented for medical research. The components of the sound level meter were all exploited for the telephone system before being combined into test instruments.

Time, frequency, and amplitude became measurable in acoustics in different centuries: time in the Seventeenth Century (transit time of sound waves in space); frequency in the Eighteenth Century (Hook and then Savart spinning a toothed wheel to match its buzz with the pitch of a sound heard by the ear); and amplitude in the Nineteenth Century (the Rayleigh disk). What profoundly new acoustic dimension has become measurable in the Twentieth Century? Clearly measurements have become much more accurate, clearly instrumentation has become much smaller, lighter, more rugged. But what can we now measure that is completely new?

Not much!

Noise dosimetry came along in the 1970's, but it is still very imperfect. Instruments for sound intensity have become practical in the last several years, but these are still very imperfect. Most importantly, these techniques are only refinements of what was available in 1917.

In 1988 Leo L. Beranek (1914-) issued a second edition of his 1949 book, *Acoustic Measurements*. In the preface he etched out the profound change in his subject, between editions. In 1949 sound level meters, the most fundamental instruments of all acoustical measurements, were seldom calibrated, grossly and unpredictably variable with temperature and humidity and age, not quite authoritative (nor even reputable) to quote, and required "a strong back or a rolling table."

Thus we can truthfully say that within the lifetimes of the people right in this room sound went from a mathematico-scientific theory to a tangible quantity we can measure as accurately as, and more easily than, voltage or resistance.

Now as we sit here in the late fall of 1991, we are entering the final decade of our century, and it isn't clear what will come next. But then, it was never clear before. Perhaps someday we will have a meter we can point at a sound, and on a screen will appear the words, "This is a really lovely rendition of Purcell's Trumpet Voluntary, but the trumpeter is getting flatter by the moment. Oh, and by the way, I wish those people in the balcony would stop whispering." It's not out of the question.

THE QUALITY OF THE QUANTIFICATION

The core of the problem we face now, even if we wish it would go away, is this: upon what information, and with what accuracy, could such a wondrous device operate?

We have at our fingertips software that allows us to build models, define and predict the behavior of devices, and spaces, and even simulate the acoustic signatures of rooms not yet built. Yet what we have failed to examine, in the detail and with the energy needed, is the data infrastructure upon which we all so blithely anchor our work. The numbers, and how they are created (yes, created, for we cannot use the term generated anymore) is where we should be focusing our brightest light, yet they remain locked away in the dim recesses of the microcode of our instrumentation. We now have computers taking measurements, and passing them on to other computers, with little or no human oversight. We sit there mesmerized by our ability to delve into the finest detail, yet we miss the obvious.

For example, distinct from CAD programs in use for other industries, our version of this software is like a long-lost, fourth cousin, once removed, from the CAD family. It does not use the computer to make anything, not even blueprints. It uses the computing power of the hardware to manipulate options, to display parameters, to visualize suppositional two- and three-dimensional models, to graph simulations governed by audio artifice, hypothesis, presumption, and algorithmical constraints. Yet we ignore these artifacts, and stand there with a knowing smile on our faces, convinced of the power of our own creation.

Where is the system of checks and balances?

To paraphrase Wolfgang Pauli (1900-1958), the famous nuclear physicist, measurement technology in the Twentieth Century has almost become like going to the world's finest French restaurant, and being forced to eat the menu.

To understand this issue better let's step back and look at the larger picture for a moment.

Today a vast gap exists between those who trust scientific measurements, and those who trust their ears. Some would live and die by the numbers alone. Others would as soon be deaf as judge acoustic and audio system characteristics by quantifiable variables, by measurements alone.

Essentially the two belief systems are separated by a wall of mathematics. Those who subscribe to the objective view of the universe generally require that to quantify a variable, mathematically accurate, repeatable, precise measurements of defined parameters must be made. On the other hand, the members of the subjective academy fiercely and vociferously support their contention that descriptions of sound must be couched in terms that illustrate or verbalize sonic or acoustic phenomena and effectively convey these perceived sensations to non-participants.

The same dichotomy exists between those who will use and trust AADS systems for design, and those who abhor any such approach.

For both, the key issue was and is how to portray statistically and mathematically the often nebulous or somewhat individualized subjective descriptions, yet maintain a valid scientific quantification basis for measurement and design worlds, while paying homage to the "art of sound". This is a complex juggling act indeed.

As you might expect, Richard C. Heyser (1931-1987), the father of time delay spectrometry as well as the modern school of mathematically-based audio measurements, offered wisdom on this subject. In "The Delay Plane, Objective Analysis of Subjective Properties: Part I" (*Jour. Audio Eng. Soc.*, v. 21 n. 9, 1973, pp. 690-701) he wrote:

> Any audio system can be completely *measured* by impulse response, steady-state frequency response, or selected variations of these such as square wave, tone burst or shaped pulse... [however such] measurements will unfortunately always remain unintelligible to the non-technical user of audio systems.
>
> The difficulty lies not with the user, but with the equations and method of test... for these do not use the proper coördinates of description for human identification... [We] should not expect a one-dimensional audio measurement to be meaningful in portraying an image of sound any more than [we] could expect an art critic to be appreciative of a painting efficiently encoded and drawn on a string.

He added,

> ...one commonsense fact should be kept in mind, the electrical and acoustic manifestations of audio *are* what is real.
>
> Mathematics (and its implementations) are at best a detailed simulation that we choose to employ to model and predict our observations of the real world. We should not get so impressed with one set of equations (or one measurement format or method) that we assume the universe must also solve these equations or look at things in that particular way, to function. It does not.

Heyser's prescient remarks, made almost 20 years ago, are still valid today, perhaps even more so given the progress in measurement hardware and the mathematics that enables it.

Beginning with the calculus of long ago, we have moved forward, albeit sometimes haltingly, until as the Twentieth Century closes we have reached a level in measurement technology and design software that enables us to examine, quantify, and supposedly analyze what some practical individuals have dubbed "audio minutiæ". That ability can and has led some over the cliff of reality and into the deep abyss of information for information's sake. In some bizarre form of addiction the computerized displays have themselves become a fixation.

It is crucial to remember, as we move ever further up the measurement capability ladder, two key facts:

♦ It is the non-critical, untrained ear that funds the audio industry. All of our customers, and in many cases we ourselves, could care less what the instruments say: eventually we must all base our critical judgments entirely on what we hear.

That enforced psychoacoustic scaling of what is and is not good sound leads us to point number two:

♦ The best and most accurate measurement tool available is free, and it is located on either side of your head. It serves little purpose to measure and quantify the system to the *n*th degree if your ears tell you it still sounds bad.

In the paper quoted above Dick Heyser also said: "It is... perfectly plausible to expect that a system which has a 'better' frequency response, may in fact sound worse simply because the coördinates of... measurement are not those of subjective perception."

What this all condenses down too are some critical and yet often overlooked realities:

1. The ability to quantify does not also automatically imply the ability to understand.
2. Machines and microphones do not "hear" in the same way that human beings do.
3. The ear-brain interface is a subjective analysis system. It is also a system wherein the "code" used to process the information is still little understood, and the subject of much myth.
4. Just because we can determine a parameter does not mean we actually need or can effectively use the information.
5. Despite its lack of scientifically-acceptable facts and mathematically-correct formulæ, the subjectively-based analysis of perceived acoustic or audio quality is still the measurement system that most sentient residents of this planet accept and understand.

This last point is the *most* crucial. It is fact, not supposition or theory.

Why?

Simply because human beings see objects in space and hear events in time, while measurement hardware sees photons of light and hears sound as waves. Understanding this distinction is critical, because it focusses on the essential difference between purely logic-based systems and those operating in the biological domain.

HARDWARE SPEAKS THE TRUTH—OR DOES IT?

While some would have you believe that the measurement machines and the software that drives them sit there with conclusive truth oozing from every pore, the facts may lead you to another conclusion.

For a moment, take yourself back into the world of computer design systems. Let's say that a client is presented two versions of a design, using the full graphic glory of color printers, hi-resolution graphics and all the tricks that our computer-enhanced modelling and desktop publishing systems can produce, based on data obtained from excruciatingly-expensive information acquisition systems, and ported from one electronic brain to another. What if these designs present substantially different performance prognostications? Whom are they to believe? The cynical amongst us might jump up here and say, none of the above.

This situation becomes even worse, and far more legally dangerous, when we proceed into the wonderful world of acoustic simulations, or, if you prefer, auralizations.

Let us pause for a moment, and digress, and officially dub this next segment of development the "virtual reality" era.

With that option added to the menu, one might legitimately ask, does the user of the programs, whether consultant, contractor, or other professional, risk reputation by exporting to the simulation system any one program's results instead of another's? Is there further risk to life and career by uncritically accepting the data on which the program has based its calculations? Or, should they insert their own data, which also might be subject to the insidious and often invisible assumptions programmed into the measurement acquisition system they have chosen to use?

In fact, if no one can agree on standards for measurement (as seems to be the case), does this leave the results of any analysis in doubt? Remember, what you read on the face of a meter is the bottom of the intellectual food chain, mere plankton. At this point, someone should probably stand up at the back of this room and shout, "I'm fed up and I won't take it any more, I want *real audio truth!!!*"

But wait, there's more.

Even if we explain patiently, "The simulation you are about to hear considers only the room, not the sound system," is the client, with probably no knowledge or expertise in acoustics, measurement criteria or computers, likely to assume (while being amazed *via* the headphones, or other simulation/presentation schemes), that this is reality? When we let them "listen to the drawings" while looking at a computer generated 3D model of their non-existent project in full color and motion, can we take the risk and presuppose they really understand that this is at best a sort of approximate estimate?

Even if we cover ourselves in thick blankets of disclaimers, and get signed releases, will a court of law accept those disclaimers when we are sued for a six or seven figure number of monetary units? Or, will they side with our client, because the new building (with the client's name on it in letters three meters high) does not sound or perform like the simulation we so carefully orchestrated?

It's little comfort to discover the absorption data given us were off by just a little bit. This error then cascaded through the whole chain to make the entire model a pile of steaming treacle, and now we are consulting with our solicitor (at £150 per hour) on how to stave off the imminent winding-up order. As we rush headlong into the next epoch of AADS we need to consider the following:

Remember the vast unwashed out there do not clearly understand or blindly accept what we as professionals know is a founding tenet of the computer age: the famous *GIGO* caution, *garbage in, garbage out.*

Further it is becoming more and more obvious that, in addition to graphical accoutrements in the AADS universe, the measurements (and their methodology) are now also the focus of marketing and "mine are better than yours" claims. In fact, the political, emotional, and technical realities at this point in the on-going AADS development process seem to preclude completely any widespread support (perhaps any support at all) for a "standard" measurement methodology. A recent meeting held late this summer in the U.S. on this topic was (from all reliable reports) barely able to generate very grudging agreement to the idea that perhaps, maybe we should sort of, kinda, look into some sort of semi-standardized measurement process for AADS program loudspeaker data generation, maybe! This is akin to agreeing that yes, the sun will rise tomorrow, but whether that will be in the east or the west is being taken under advisement for further study. A report may be forthcoming, sometime.

Our hardware's ability to acquire ever more information increases geometrically. Thus our continuing pursuit of ever more data on devices is now beginning to take us down some very muddy, unmarked roads. Considerable controversy continues to exist about the exact meaning of, use for, and influence of many of the parameters we so readily display, with seemingly infallible accuracy, on our CRT's. This should tell us not to be all that comfortable, or so damn sure we're right.

CONCLUSIONS

The reasonable path to take is one of enlightened caution, until empirically-produced, definitive comparisons can be performed, in a scientifically-proper manner, comparisons that either statistically verify or discount the accuracy of the information.

The more we try to cram into these systems to be manipulated and processed, the bigger the quantitative and qualitative error factor will have to get. The accumulation of small inaccuracies will be continually magnified by each new layer of assumptions that do not revalidate or recheck the steps before, until eventually the whole delicately-balanced construct crashes.

Professional practitioners should remember that objective measurements supply a repeatable reference, and can and should be an integral part of any complete analysis of a system. But, since the systems we all consult on, specify, design or install are to be used by human beings and not machines, we'd best also remember that those making these somewhat less scientific subjective judgments are also the ones who will eventually issue the cheque!